

CLAIMS

1. A nitriding treatment method for performing a nitriding treatment for a workpiece (12) in a heat treatment furnace (24), said nitriding treatment method comprising:

a first step of applying a pulse voltage having a predetermined current density at a frequency of not less than 1 kHz between said heat treatment furnace (24) and said workpiece (12) to heat said workpiece (12) by means of generated glow discharge; and

a second step of decreasing said current density of said pulse voltage after a temperature of said workpiece (12) arrives at least at 350 °C, while heating said workpiece (12) up to a desired nitriding treatment temperature by using a heating element (34) arranged around said workpiece (12), wherein

said nitriding treatment is performed by means of nitrogen ion or nitrogen radical generated by said glow discharge.

2. The nitriding treatment method according to claim 1, wherein

said workpiece (12) is heated by heat generated by said glow discharge and said heating element (34) in said first step; and

heating is effected in said second step such that an amount of heat generated by said heating element (34) is

higher than that in said first step.

3. The nitriding treatment method according to claim 1, wherein said current density of said pulse voltage is gradually decreased in said second step, while said workpiece (12) is gradually heated up to said nitriding treatment temperature by using said heating element (34) arranged around said workpiece (12).

4. The nitriding treatment method according to claim 1, wherein said nitriding treatment temperature is maintained to execute said nitriding treatment after said workpiece (12) arrives at said desired nitriding treatment temperature in said second step.

5. The nitriding treatment method according to claim 1, wherein said current density of said pulse voltage is 0.05 to 7 mA/cm².

6. The nitriding treatment method according to claim 1, wherein said current density of said pulse voltage is 0.1 to 4 mA/cm².

7. The nitriding treatment method according to claim 1, wherein said temperature of said workpiece (12) is determined by detecting a temperature difference between a radiation temperature and a contact temperature of a dummy

workpiece (36) arranged in said heat treatment furnace (24), detecting a radiation temperature of said workpiece (12), and correcting said radiation temperature of said workpiece (12) with said temperature difference.

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8. A nitriding treatment apparatus for performing a nitriding treatment for a workpiece (12) in a heat treatment furnace (24), said nitriding treatment apparatus comprising:

10 a glow discharge-generating means (48) which generates glow discharge by applying a pulse voltage having a predetermined current density at a frequency of not less than 1 kHz between said heat treatment furnace (24) and said workpiece (12);

15 a heating means (50) which heats said workpiece (12) by using a heating element (34) arranged in said heat treatment furnace (24);

a temperature-detecting means (58) which detects a temperature of said workpiece (12); and

20 a control means (74) which controls said current density of said glow discharge effected by said glow discharge-generating means (48) on the basis of said temperature of said workpiece (12) detected by said temperature-detecting means (58) and which controls said heating means (50).

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9. The nitriding treatment apparatus according to claim 8, wherein said heat treatment furnace (24) includes:

a nitriding treatment chamber (32) which accommodates said workpiece (12) and which is surrounded by an electrode plate (45) for generating said glow discharge in cooperation with said workpiece (12);

5 a heating chamber which involves said heating element (34) arranged around an outer circumference of said electrode plate (45) and which is surrounded by a partition wall (28); and

10 a cooling means (33) which is arranged around an outer circumference of said partition wall (28) and to which a cooling liquid for cooling said partition wall (28) is supplied.

15 10. The nitriding treatment apparatus according to claim 8, wherein said temperature-detecting means (58) includes:

 a dummy workpiece radiation thermometer (54) which detects a radiation temperature of a dummy workpiece (36) arranged in said heat treatment furnace (24);

20 a dummy workpiece contact thermometer (56) which detects a contact temperature of said dummy workpiece (36);

 a workpiece radiation thermometer (52) which detects a radiation temperature of said workpiece (12); and

25 a workpiece temperature-calculating means (58) which calculates said temperature of said workpiece by calculating a temperature difference between said radiation temperature and said contact temperature of said dummy workpiece (36)

and correcting said radiation temperature of said workpiece with said temperature difference.

5 11. The nitriding treatment apparatus according to claim 8, wherein said heat treatment furnace (24) is a lateral type heat treatment furnace.

10 12. The nitriding treatment apparatus according to claim 8, wherein said workpiece (12) is a crank shaft.